ISSN 1755-5361

University of Essex

Department of Economics

Discussion Paper Series

No. 676 November 2009

Ownership, Control, and Incentive

Tianxi Wang

Ownership, Control, and Incentive

Tianxi Wang*

Abstract

The paper shows that the principal can enhance her control over the agent's human capital by acquiring the physical capital that is critical for him to create value. However, the enhancement in the control necessarily reduces his incentive to make human capital investment ex ante and to exert effort ex post. This trade-off between control and incentive thus decides the boundary of the firm. The paper also presents a rationale for M-form firms: centralized ownership of physical capital to facilitate coordination, and dispersed payoff rights to incentivize divisions.

Key Words: Ownership of Physical Capital Control over Human Capital Incentive The Boundary of the Firm M-Form Firm

D23, D82

*University of Essex. Correspondence: Department of Economics, University of Essex, Wivenhoe Park, Colchester, CO4 3SQ, United Kingdom. Email: wangt@essex.ac.uk. The paper was circulated with the title "Control versus Incentive – the Boundary of the Firm". I am grateful to Leonardo Felli, John Moore, and Andrea Prat for their advice.

1 Introduction

Ronald Coase (1937) initiated the inquiry into the nature of the firm. He believed, and so did Simon (1951), Williamson (1975) among many others, that the firm, as is different from the market, is defined by authority. This belief was criticized as "delusion" by Alchian and Demsetz (1974), who asserted that the firm has no authority any different from ordinary market contracting and that "(the employer) can fire or sue, just as I can fire my grocer by stopping purchases from him or sue him for delivering faulty products." This paper tries to reconcile the two sides, by showing that the principal can enhance her control over the agent's human capital by acquiring the physical capital critical for him to create value. The literature on the theory of the firm overwhelmingly concentrates on incentives, but touches control (or coordination) only lightly, as Holmstrom and Roberts (1998) have noted. While the literature on the allocation of decision rights is related to control, it presumes that decision rights can be moved freely, namely the control over the agent's human capital is always successful when it is indispensable. This paper is one of few that address how inter-personal relationships change across the boundary of the firm.

The paper explicitly differentiates control problems from incentive problems. Both refer to situations where the principal wants the agent to make a preferable choice among ex ante uncontractible actions. Control problems differ from incentive problems in ex post contractibility of the choice. If on the time when the choice is being decided, it is contractible and hence negotiated between the two parties, it is a control problem, and if not, an incentive problem. For example, it is a control problem to ensure G. W. Bush to or not to invade Iraq, but it is an incentive problem to ensure him to spend more time considering serious stuff rather than having fun, as he claimed that he was working even in his Texas farm.

Control is modelled in this paper as the choice between two projects, to be done with a capital: the general project that supplies the market, or the specific project that supplies the principal solely. To accomplish either project relies on the agent's human capital. Therefore, the principal, no matter if acquiring the capital, has to bargain with him on the project choice. They have equal bargaining power, that is, each has one half chance to make a take-it-or-leave-it offer (tioli) to the other. On the other hand, the capital is critical for the agent to create any value. The value of either project depends on the agent's human capital investment ex ante and his effort ex post. Both are chosen privately by him, not subject to bargaining; the choices are thus of incentive problems.

The last ingredient of the model is the friction of bargaining, without which Coasian bargaining always pick the ex post efficient project, whoever owns the capital. In the paper, the friction is information asymmetry. Roughly, at the date of negotiating the project choice, the agent knows the value of the general project, while the principal knows only its distribution.

In this set-up, in order to incentivize the agent, he should always have the payoff rights of the capital, that is, own the project's product, since the value of the product is not contractible, as in Grossman and Hart (1986). Moreover, control entails incentive loss. Control means to do the specific project, which captures win-lose coordination leading the agent into a hold-up situation. Indeed, if doing the specific project, he only reaps half of its value, since the principal is the only buyer of his product. On the contrary, he obtains the full value of the general project. Therefore, there is a trade-off between control and incentive.

The allocation of ownership of the capital affects the default project, namely the project that is chosen when there is no bargaining or bargaining reaches no agreement. The default choice affects the equilibrium choice when the principal offers tioli (while when the agent offers tioli, the project choice follows ex post efficiency since the principal has no private information).

Consider first the case of principal-ownership. The default choice is the specific project: it is not the general project, since the principal, now the owner of the capital, gets nothing immediately from the project; it is not null project either: leaving the principal and thus the capital, the agent can do nothing and gets nothing. Therefore, if the agent wants to do the general project, he has to buy the principal's assent with side payment. On the default option, she obtains half of the specific project's value. When she offers tioli, therefore, she asks for a price beyond the half value by a positive difference. The agent accepts the asked price, in order to do the general project, only if its value is no less than the sum of the price plus his value from the default option, half of the specific project's value. Therefore, the general project is chosen only if its value is beyond the specific's plus the positive difference. It follows that when the general project is worth more than the specific but less than the latter plus the difference, it is socially efficient but not chosen. That is, principal-ownership induces *too much* control.

Consider then the case of agent-ownership. Now the default choice is the general project since he gets nothing immediately from the specific project. If the principal wants him to work for her, to do the specific project, she has to buy his assent with side payment. On his assent, she gets half of the specific project's value. When she offers tioli, therefore, she offers a price below the half value by a positive difference. If accepting the offer, the agent obtains the price plus half of the specific project's value. The offer is accepted, so the specific project is chosen, therefore, only if the general project is worth less than the specific project minus the difference. It follows that when the general project is worth more than that but less than the specific project, it is socially inefficient but is chosen, that is, there is *too little* control.

Centralized ownership under the principal, therefore, implements more win-loss coordination, and also induces more incentive losses, than decentralized ownership. This is consistent with Chandler (1977)'s documentation that vast amounts of assets were put under centralized ownership, which generated giant US corporations, only when transactions were better coordinated by direction of mangers within the firm than by the market. Moreover, note that principal-ownership in this paper captures the M-form firm, of which the agent is a division: ownership of physical capital is centralized under the principal, but the agent keeps the payoff rights of his division. This paper therefore presents a new rationale for the M-form firm: centralized ownership of physical capital to facilitate win-loss coordination and dispersed payoff rights to incentivize divisions.[1]

The paper is related to the literature on the theory of the firm, to the literature on the allocation of decision rights, and most closely, to several recent papers on authority and the boundary of the firm.

The literature on the theory of the firm touches the control side only lightly. A good survey is provided by Gibbons (2004), who classifies the literature into four categories which are to be examined in order. The property rights theory (Grossman and Hart (1986), Hart and Moore

[1]For other research on M-form and U-form firms, see Maskin et al (2000) and Qian et al (2006).

(1990) and Hart (1995); GHM hereinafter) is concerned with suboptimal provision of ex ante (human capital) investment. The level of the investment is not decided by bargaining when it is being laid down, though observable afterwards; otherwise, the hold-up problems evaporate. The incentive theory (Holmstrom and Milgrom (1991, 1994), and Holmstrom (1999) etc.) is concerned with the balance of the incentive of exerting effort between multiple tasks or between multiple agents. Similarly, the quasi-rent seeking theory (Baker and Hubbard (2000) etc.) is concerned with how the allocation of ownership of physical capital affects the incentive balance between rent seeking and doing the assignment for the principal. In either category, the level or the distribution of the effort is decided by the agent privately, not even observable to the principal, and is thus of incentive problems. Therefore, the above three categories of literature address the incentive side only, not the control side (as is defined in this paper). The fourth and the last category, relational adaptation theory (Simon (1951) and Williamson (1975, 1991) etc.), pays attention to control. The comparison to it is detailed below.

The literature on the allocation of decision rights is also voluminous, tracing back to Simon (1951) and recently including Athey and Roberts (2001), Aghion et al (2004), Bolton and Dewatripont (2005), Dessein et al (2007), Friebel and Raith (2007), Alonso et al (2008), Baker et al (2008), and Rantakari (2008).[2] This literature assumes away ex post bargaining and presumes that decision rights are freely moveable. In most cases, however, the action under decision has to be carried out by the agent even if he has no formal decision rights, like the case of this paper where the capital has to be operated with by the agent. For these cases, the literature presumes that control over his human capital is always successful, while this paper advances one step further and examines this presumption.

The paper is most closely related to Hart and Holmstrom (2009) and Van den Steen (2009). Similar to this paper, Hart and Holmstrom (2009) derives that integration induces too much

[2]Among them, Athey and Roberts (2001), Dessein et al (2007), and Friebel and Raith (2007) derive a trade-off between coordination and incentive, from the tension that to encourage coordination, the agent should be rewarded based on overall performance measure, but to elicit effort, narrowly on effort-related performance measure. In contrast, the trade-off arises in this paper because of the hold-up problem which win-loss coordination entails. Williamson (1975, 1991) also informally expounds a similar trade-off, between adaptation and incentive.

coordination and non-integration too little. This paper differs from theirs in two aspects. Their paper, as the literature on decision rights, assumes away ex post bargaining and presumes successful control. And the cost side of integration in their paper is the (assumed) reduction in the private benefits caused by coordination, while that in this paper is incentive losses. Van den Steen (2009) considers, similarly, how centralized ownership of physical assets and low-powered incentives give the principal authority over the agent.[3] His paper is driven by the assumption that the two have differing priors, while this paper makes no such an assumption and adopts a conventional approach.[4] Moreover, this paper is richer than his paper, in the sense that authority in the manner of his paper is a feasible but dominated arrangement in this paper: when the principal gets the payoff rights of the capital and the agent is paid thus with a fixed wage, he is willing to do whatever project dictated by the principal; this arrangement, however, is dominated since it induces too much incentive loss (see Subsection 3.3 below).[5] This paper's point of view is that as employees of critical human capital are concerned, the boss may never have dictating authority over them in the manner of Van den Steen (2009) and what is described in this paper is more likely to happen.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 analyzes all the possible contractual arrangements (called regimes) one by one. Then they are compared in Section 4 to find the equilibrium arrangement. Section 5 presents empirical evidences and lastly, Section 6 concludes.

[3] And Van den Steen (2006) derives, in a different set-up, a trade-off between coordination and incentive, which is also driven by differing priors.

[4] The assumption gives rise to the concern on how to decide ex ante efficiency and hence the equilibrium arrangement. With the assumption, maximizing the sum of the two parties' expected utilities is not satisfactory, because at least one party's assigned probability is wrong; moreover, the sum can be made arbitrarily large by having the two parties bet on the state.

[5] This argument shows that low-powered incentives alone suffice to ensure authority.

2 The Model

The model consists of a principal (denoted by P), an agent (A) and a capital.[6] Both players are risk neutral. The capital is indispensable for A to create value, and on the other hand, A's human capital is indispensable for it to be utilized. With the capital, A could engage into two exclusive projects. One aims to coordinate with P's integrated strategy and leads to a specific product useful to none but P. The other project aims to supply the market and leads to a product of general interest. The specific project captures win-lose coordination and is denoted by "**s**", and the general project is denoted by "**g**".

The value of either product depends on the human capital investment A makes before the project is chosen and the effort level he exerts in doing the chosen project. Either the investment or the effort suffices to capture the incentive side. Nevertheless, both are introduced, the effort introduced to show that the theory of the paper does not rely on investment specificity and the investment introduced to show that the theory is rich enough to cover ex ante incentives.

Timing:

There are five dates. At date 0, P and A decide the allocation of ownership and payoff right of the capital. Here ownership means, following GHM, residual control rights, namely that the owner can always walk away from bargaining with the capital and put it in an alternative usage, if she or he wishes. And payoff rights here mean the ownership of the project's product. At date 1, A makes the human capital investment. At date 2, the state is realized, and P and A negotiate the project to be done. At date 3, A chooses the level of the effort to do the chosen project. At date 4, the product of the project is yielded, and is traded if P has no payoff rights. An arrangement of the ownership and payoff rights of the capital is called a "*regime*". The timing is illustrated in figure 1 below.

[6] Implicitly, P has owned some other capital. The assumption, then, is that this capital is of such a vast size that A can never take over P. Therefore, unlike Grossman and Hart (19086), this paper only examines one direction of integration, namely P acquiring A, and the model captures the situations between a large company (P) and a small team (A), not that between two equals.

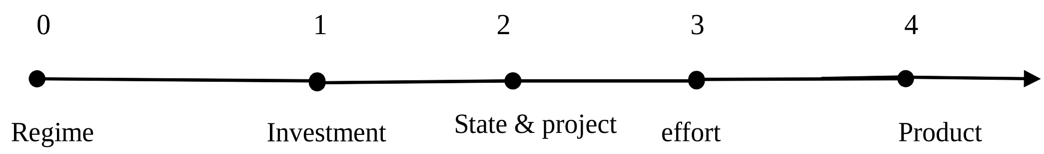

Figure 1: Timing Tree

The values of the two products are as follows. If A invests $i \in [0, \infty)$ at date 1 and exerts effort $e \in [0, \infty)$ at date 3, and the realized state is t, then the value of the specific product is $v_s(i, e)$ and the market price of the general product is $v_g(i, e; t) = tv_s(i, e)$. Assume $t \in [0, 1]$, that is, given the investment and effort levels, the specific project is always worth more than the general project; the excess is the benefit of coordination. To capture this benefit, let $v_s(i, e) = d(i, e) + B$, where $d(i, 0) = d(0, e) = 0$ and $B \geq 0$; thus B has no incentive effect upon i or e and captures only the benefit of coordination. Denote by $c_i(i)$ the cost of investing i and by $c_e(e)$ the disutility of exerting effort e. Assume that the value functions are strictly increasing and concave and that the cost functions are strictly increasing and convex.

Information:

The project choice is not contractible before date 2 and is contractible and negotiated between P and A at the date. It is thus of a control problem. We call it "*loss of control*" (for P) if the specific project is not chosen at date 2. The investment level, i, is not contractible and decided privately by A at date 1, but observable at date 2, as in GHM. The effort level, e, is never observable to P, as in a typical moral hazard problem. The choices of i and e are thus of incentive problems. The value of the product is never contractible but observable at date 4, as in GHM. This bears two implications: one, no contract is feasible to incentivize A except giving him the payoff rights; and the other, even when A obtains the payoff rights, he will be held up by P if doing the specific project, since she is then the only buyer of his product.

Assume state $\widetilde{t}$ uniformly distributes on $[0, 1]$ before date 2. At date 2, only A knows privately its realized value, t, while P still knows only its distribution. Information asymmetry is to capture bargaining costs.

Assumption (Incomplete Contracting): at date 0, P and A do nothing but decide the allocation of the ownership and payoff rights of the capital.

To be sure, P and A could learn a lot from the implementation theory to design some mechanisms on how to choose the project at date 2 and on how to trade the product at date 4, which is, however, assumed away. See Hart (1995) and Hart and Moore (1999) for some justifications for this assumption.

By the assumption, the project choice is decided via bargaining between P and A at date 2, and if A has the payoff rights, the price of the specific product is decided via bargaining at date 4. Assume that P and A have equal bargaining power, that is, each party has $\frac{1}{2}$ chance to make a take-it-or-leave-it (tioli) offer to the other.

At date 0, P and A choose one out of the four following alternative regimes. The equilibrium regime will be the one that maximizes the total surplus of P and A, as side payment of any amount is feasible.

Regime 1: A has the ownership and the payoff rights of the capital.

Regime 2: P owns the capital and A has the payoff rights.

Regime 3: A owns the capital and P has the payoff rights.

Regime 4: P has the both.

Under regime 1, A is an independent contractor. Under regime 2, he is a division of the M-form firm, in the sense that ownership of non-human capital (this and P's other capital) is centralized in the hands of P, but A has an independent account and owns what he produces. Regime 3 is an exclusive dealing arrangement, as A can only supply P. Under regime 4, A is a salaried employee of P. It will be shown that regimes 3 and 4 are dominated by regime 1 or 2. Thus what matters is the allocation of ownership of the capital. To justify regimes 3 and 4 we could introduce the value of the capital in a manner of Holmstrom and Milgrom (1991), which is not pursued here.

The next section finds out the outcome under each of the four regimes with backward induction.

3 The Four Regimes

3.1 Regime 1: Independent Contractor

Under regime 1, A is an independent contractor of P and has both the payoff rights and ownership of the capital.

At date 4, A owns the product of the chosen project. If it is the general product, then he sells it at price v_g. If it is the specific product, he bargains with P on its price, which will be half of its value, $\frac{1}{2}v_s$, as they have equal bargaining power.

At date 3, the effort level is chosen to maximize $v_g(i, e; t) - c_e(e)$ if the general project is chosen, or to maximize $\frac{1}{2}v_s(i, e) - c_e(e)$ if the specific project is chosen. Note that $v_g(i, e; t) = tv_s(i, e)$, so the two problems can be unified. Let $e(i, t) \equiv \max_e tv_s(i, e) - c_e(e)$ and $V(i, t)$ be the maximum value. , namely, $V(i, t) = tv_s(i, e(i, t)) - c$ of the problem , and $e(i, t)$ be the maximizer, Suppress argument i when we are discussing what happens after date 1. Then, A chooses effort level of $e(t)$ for the general project and that of $e(0.5)$ for the specific project, and $V(t) = tv_s(e(t)) - c_e(e(t))$. At the end of date 2, the social value of the general project is $V(t)$ and that of the specific project is $v_s(e(0.5)) - c_e(e(0.5)) = V(\frac{1}{2}) + \frac{1}{2}\widehat{v}$, where $\widehat{v} \equiv v_s(e(0.5))$. Define $\widehat{t}$ as follows.

$$V(\frac{1}{2}) + \frac{1}{2}\widehat{v} = V(\widehat{t}) \tag{1}$$

Then $\widehat{t} > \frac{1}{2}$, and when $t > \widehat{t}$, the general project is efficient, because the specific project induces incentive loss $(e(t) > e(0.5))$; the specific project is efficient when $t < \widehat{t}$, namely when the incentive loss is not big.

At date 2, P and A negotiate the project to be done, as follows. Since A owns the capital and the final product under the regime, he can go directly for the general project, if he wishes. Or he chooses to bargain with P on the price which she pays for him to do the specific project. If he chooses so, the nature decides who has the chance to make a take-it-or-leave-it (tioli) offer to the other. With probability 0.5, A offers tioli to P; if she takes it, the specific project is chosen; if she leaves it, A comes back to the general project. With probability 0.5, P offers tioli to A; if A takes it, the specific project is chosen; if A leaves it, he comes back to the general project. Thus events tree is the following:

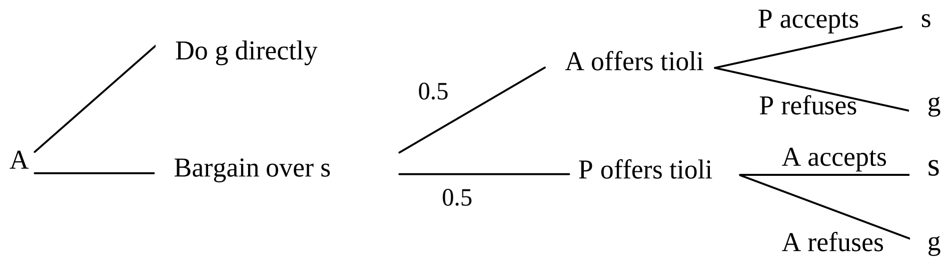

Figure 2: the events tree of bargaining on the project choice under regime 1

"g" represents the general project and "s" the specific

Notice that in the bargaining game, at stage 1 strategy "do g directly" is weakly dominated to A by "bargain over s" for any realized state t, because choosing to bargain, he can still pick "g" with certainty, if he wishes, simply by rejecting P's offer or tendering P with an unacceptable offer. Thus, at stage 1, A always chooses to bargain and this choice signals nothing of A's private information. Denote by F the price P pays to A. From the specific project, P obtains half of the specific product's value, $\widehat{v} \equiv v_s(e(0.5))$. Therefore, she will reject any asked price $F > \frac{1}{2}\widehat{v}$. A will ask $\frac{1}{2}\widehat{v}$ exactly when he offers tioli and wants it to be accepted, which then gives him $V(\frac{1}{2}) + \frac{1}{2}\widehat{v}$. He obtains $V(t)$ if the tioli is rejected and he goes for the general project. In case of A offering tioli, therefore, his payoff is $\max\{V(\frac{1}{2}) + \frac{1}{2}\widehat{v}, V(t)\}$, and the project choice is efficient: the specific project is chosen if and only if $t \leq \widehat{t}$, which is because P has no private information.

Consider the case when P offers tioli, F. In state t, A gets $V(t)$ from rejecting the offer, and $V(\frac{1}{2}) + F$ from accepting it. It is accepted, therefore, if and only if $V(\frac{1}{2}) + F \geq V(t)$. The following happens.

Lemma 1 *P will offer $F = 0$ and A accepts it if and only if $t \leq 0.5$.*

Proof. *When having the chance to offer tioli, P faces a monopolist's pricing problem:* $\max_F \Pr(\widetilde{t}|V(\frac{1}{2})+F \geq V(\widetilde{t}))(\frac{1}{2}\widehat{v} - F)$. *By the variable transformation* $F = V(t) - V(\frac{1}{2})$, *the problem becomes* $\max_t \Pr(\widetilde{t} \geq t)(\frac{1}{2}\widehat{v} + V(\frac{1}{2}) - V(t)) = \max_t t(\frac{1}{2}\widehat{v} + V(\frac{1}{2}) - V(t))$, *given t is distributed uniformly. Apply the envelop theorem,* $V'(t) = v_s(e(t))$, *the first order condition of the problem is* $\frac{1}{2}\widehat{v} + V(\frac{1}{2}) - V(t) - tv_s(e(t)) = 0$. *It is easy to see that $t = \frac{1}{2}$ is a solution as $\widehat{v} = v_s(e(0.5))$. And it is the unique solution, since $V(t) + tv_s(e(t))$ is an increasing function of t as $e(t)$ is increasing.* ■

The two cases are summarized in the following lemma.

Lemma 2 *Under regime 1, the specific project is certainly chosen if $t \leq 0.5$, it is chosen with probability $\frac{1}{2}$ if $0.5 < t \leq \widehat{t}$, and it is not chosen if $\widehat{t} < t$. Therefore, with probability $1 - \widehat{t} + \frac{\widehat{t} - 0.5}{2}$ there is loss of control.*

Note that when $0.5 < t \leq \widehat{t}$, the specific project is not chosen when P offer tioli, even though it is the efficient one. Thus,

Corollary 1 *Regime 1 induces too little coordination: the specific project is chosen only if it is efficient, and with probability $\frac{\widehat{t} - 0.5}{2}$, it is not chosen even if it is efficient.*

After figuring out what happens at date 2, we go backward to date 1 and date 0. We can figure out the expected utility of A after investing i, denoted by $U^1(i)$, and the expected social surplus, denoted by $W^1(i)$. Then, at date 1, A invests $i^1 = \arg\max_i U^1(i) - c_i(i)$. At date 0, the expected social surplus under regime 1 is $W^1 = W^1(i^1)$.

3.2 Regime 2: the M-form Firm

Under this regime, A is a division of the M-form firm: ownership of physical capital is centralized in the hands of P, but A keeps an independent account and owns the final product.

At date 4, A owns the product of the chosen project, as under regime 1. So he gets v_g from the general project and $\frac{1}{2} v_s$ from the specific project. And at date 3, the effort level is $e(t)$ for the former and $e(0.5)$ for the latter, all the same as under regime 1.

At date 2, the difference from regime 1 presents itself. Under regime 1, the default project is the general project, that is, A goes for the general project when he chooses not to bargain with P or bargaining fails to reach any agreement, because he owns the capital under regime 1 and gets nothing immediately from the specific project before any side payment made by P to him. Under regime 2, in contrast, P owns the capital and gets nothing immediately from the general project, which, therefore cannot be the default project. The default project cannot be null project either: the capital is critical for A to create value, so without it, A gains nothing, and hence A's threat to leave P and thus the capital is not credible. The default project under regime 2, therefore, must be the specific project. The change of ownership of the capital alters the default project.

Under regime 2, if A wants to do the general project, he has to bargain with P on the price for her approval. The bargaining process is similar to that of regime 1, differing only in the default project. At stage 1, A chooses either to do the specific project directly or to bargain over the price to buy P's approval of the general project. If he chooses the latter, then with probability 0.5, A offers P a tioli; if she takes it, the general project is chosen; if she leaves it, A comes back to the specific project. And with probability 0.5, P offers A a tioli price; if he takes it, the general project is chosen; if leaving it, he comes back to the specific project. The events tree is the following:

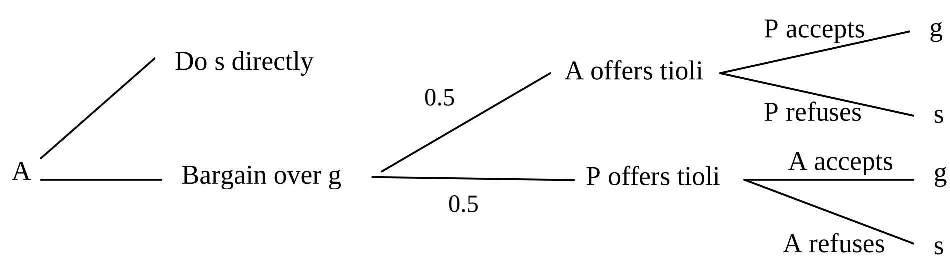

Figure 3: the events tree of bargaining on the project choice under regime 2

"s" represents the specific project and "g" the general

Similarly, strategy "do s directly" is weakly dominated to A in any realized state at stage 1, and hence A always chooses to bargain and this signals nothing of his private information. P gets $\frac{1}{2}\widehat{v}$ from the default project, namely the specific project, and she gets nothing immediately from the general project. To buy her approval for it, A has to pay $F \geq \frac{1}{2}\widehat{v}$. He will actually pay $F = \frac{1}{2}\widehat{v}$, if he offers tioli, by which he gets $V(t) - \frac{1}{2}\widehat{v}$, while he gets $V(\frac{1}{2})$ from the specific project. Therefore, when A offers tioli, he gets $\max\{V(\frac{1}{2}), V(t) - \frac{1}{2}\widehat{v}\}$, exactly $\frac{1}{2}\widehat{v}$ less than $\max\{V(\frac{1}{2}) + \frac{1}{2}\widehat{v}, V(t)\}$ (what he get under regime 1), and the project choice follows ex post efficiency. That is, when A offers tioli, ownership of the capital is only equivalent to a transfer of $\frac{1}{2}\widehat{v}$, and bears no effect on the project choice, because P has no private information. What happens when P offers tioli is summarized in the lemma below.

Lemma 3 *P asks price $\widehat{F} \geq \frac{1}{2}\widehat{v}$, and the strict inequality holds when the ex post incentive matters, that is, $e(t)$ strictly increases with t.*

Proof. By the argument above, A accepts the asked price F if and only if $V(t) - F \geq V(\frac{1}{2})$. If he accepts it, P gets F; otherwise she gets $\frac{1}{2}\widehat{v}$. Her problem is thus to choose F to maximize $Q(F) \equiv \Pr(F)F + (1 - \Pr(F)\frac{1}{2}\widehat{v} = \Pr(F)(F - \frac{1}{2}\widehat{v}) + \frac{1}{2}\widehat{v}$, where $\Pr(F) \equiv \Pr\{\widetilde{t}|(V(\widetilde{t}) - F \geq V(\frac{1}{2})\}$ denotes the probability of A accepting F. First, the optimal price $\widehat{F} \geq \frac{1}{2}\widehat{v}$, since $Q(\frac{1}{2}\widehat{v}) = \frac{1}{2}\widehat{v}$, and $Q(F) < \frac{1}{2}\widehat{v}$ for any $F < \frac{1}{2}\widehat{v}$. Intuitively, P gets already $\frac{1}{2}\widehat{v}$ from the default option and it is strictly dominated for him to ask for less.

Second, when $e(t)$ strictly increases with t, $V(1) = v_s(e(1)) - c_e(e(1)) > v_s(e(\frac{1}{2})) - c_e(e(\frac{1}{2})) = \frac{1}{2}\widehat{v} + V(\frac{1}{2})$, where the first strict inequality applies the fact that $e(1)$ is the solution of $\max_e v_s(e) - c_e(e)$ but $e(\frac{1}{2})(< e(1))$ is not. Then, for some sufficiently small $\varepsilon > 0$, $\Pr(\frac{1}{2}\widehat{v} + \varepsilon) > 0$ and hence $Q(\frac{1}{2}\widehat{v} + \varepsilon) > \frac{1}{2}\widehat{v}$. Therefore, $\widehat{F} > \frac{1}{2}\widehat{v}$. ■

Define $\widehat{T}$ as follows.

$$V(\frac{1}{2}) + \widehat{F} = V(\widehat{T}) \tag{2}$$

Then, by the lemma and (1), $\widehat{T} \geq \widehat{t}$ and $\widehat{T} > \widehat{t}$ when the ex post incentive matters. A takes P's tioli if and only if $t \leq \widehat{T}$. Then the two cases can be summarized as follows.

Lemma 4 *Under regime 2, the specific project is certainly chosen if $t < \widehat{t}$, it is chosen with probability $\frac{1}{2}$ if $\widehat{t} \leq t \leq \widehat{T}$, and it is not chosen if $\widehat{T} < t$. Therefore, with probability $1 - \widehat{T} + \frac{\widehat{T} - \widehat{t}}{2}$ there is loss of control.*

Note that if $\widehat{t} < t$ the general project is socially efficient. However, under regime 2, if $\widehat{t} \leq t \leq \widehat{T}$, it is chosen only with probability $\frac{1}{2}$. Therefore,

Corollary 2 *Regime 2 induces too much coordination: the specific project is chosen whenever it is efficient, and with probability $\frac{\widehat{T} - \widehat{t}}{2}$, it is chosen even if it is not efficient.*

As under regime 1, we go backward to date 1 and date 0. We can figure out the expected utility of A after investing i under the regime, denoted by $U^2(i)$, and the expected social surplus, denoted by $W^2(i)$. Then at date 1, A invests $i^2 = \arg\max_i U^2(i) - c_i(i)$. And at date 0, the expected social surplus under regime 2 is $W^2 = W^2(i^2)$.

3.3 Regimes 3 and 4: Authority

Under both regimes, at date 4 since P has the payoff rights, A just delivers whatever he has produced to P. Thus A gets 0 at the date, whatever his effort level and the project are. Thus he chooses the lowest level of effort, that is, $e = 0$ at date 3.

At date 2, since A's continuation value is always 0, whatever the project to be done is, he is indifferent with the project choice and just follows the choice dictated by P, who has thus interpersonal authority over the agent, in the manner of Van den Steen (2009). Then the specific project is chosen certainly. And at date 2, the social surplus is $v_s(0) - c_e(0)$, which is strictly smaller than $v_s(e(0.5)) - c_e(e(0.5))$, the minimum social surplus under the regime 1 or 2 (the surplus for $t \leq 0.5$), when the ex post incentive matters.[7] Therefore, under both regimes 3 and 4, there is no loss of control, but there is a severe loss of ex post incentive, which makes regimes 3 and 4 dominated by regime 1 or 2 in ex post efficiency.

At date 1, regimes 3 and 4 also induces severe ex ante incentive loss, due to the specific assumption that the two incentive variables are complement. Remember $v_s(i, e) = d(i, e) + B$. B has no incentive effect and $d(i, 0) = 0$ for any i. Since A is going to choose $e = 0$ at date 3, he chooses $i = 0$ at date 1. Then the two regimes are dominated by regime 1 or 2 in ex ante efficiency also. Summarily we have

Lemma 5 *Under regimes 3 and 4, there is no loss of control but a severe loss of both ex ante and ex post incentive ($i = e = 0$). The two regimes are thus dominated by regime 1 or 2.*

We move on to compare the four regimes to find the equilibrium one. By this lemma, the race is between regimes 1 and 2. Following Grossman and Hart (1986), regime 2 is called "*integration*" and regime 1 "*non-integration*".

[7] $[v_s(e(t)) - c_e(e(t))]' = (v_s' - c_e')e'(t) = (1-t)v_s'e'(t) > 0$, when $e'(t) > 0$, where the last equation applies the first order condition for $e(t)$: $tv_s'(e) = c_e'(e)$.

4 The Equilibrium Regime: Control versus Incentive

In this model, control entails incentive loss. Control means to do the specific project, namely, to implement the coordination, the win-lose nature of which implies that A is to be held up by P. Indeed, if doing the specific project, A only reaps half of its value, since P is the only buyer of its product. On the contrary, he reaps the full value if doing the general project. Therefore, A is less incentivized when doing the specific project than when doing the general one.

There are two dimensions of incentive, i and e, which are to be separated: when one is being considered, the level of the other is fixed. First consider the case of the ex post effort and thus fix the choice of ex ante investment.

4.1 Control versus Ex Post Incentive (e)

In this subsection, suppose $i = \bar{i}$ (by assuming $c_i' = \infty$ for $i > \bar{i}$; is reasonably small but still positive for $i < \bar{i}$). As before, for simplicity, argument $\bar{i}$ is suppressed in this subsection. And assume ex post incentive matters, that is, $e(t)$ is strictly increasing. Then $\widehat{t} < \widehat{T}$.

At date 2, the second best choice is to pick the specific project if $t \leq \widehat{t}$ and the general project if $t > \widehat{t}$. However, different from the second best case, the specific project is chosen only with probability 0.5 if $0.5 < t < \widehat{t}$ under regime 1 (by Lemma 2), and it is still chosen with the probability 0.5 if $\widehat{t} < t < \widehat{T}$ under regime 2 (by Lemma 4). All these three cases are contrasted in figure 3, which pictures the probability of the specific project being chosen as a function of t in the three cases.

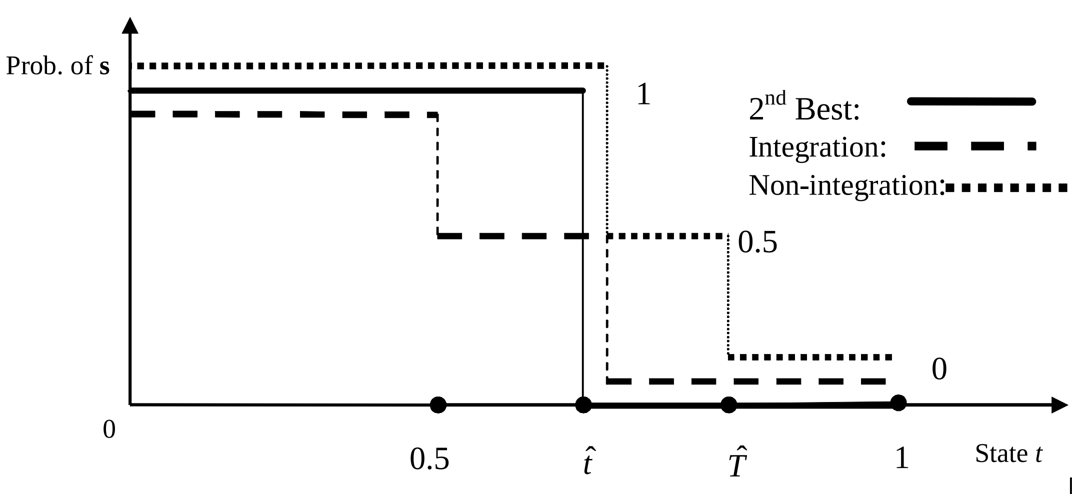

Figure 4: the comparison between the second best and regime 1 and regime 2

The vertical axis is the probability of the specific project being chosen; the horizontal axis is state t.

According to the figure, the following proposition is straightforward.

Proposition 1 *Fix* $i = \bar{i}$. *Integration brings about more control than non-integration, in the sense of a higher probability with which the specific project is chosen, but integration induces loss in the agent's incentive of exerting effort. Compared to the second best case, integration induces too much coordination but non-integration induces too little.*

The proposition hints that integration happens if and only if the benefit of coordination is larger enough. The benefit is measured by $B = v_s(e) - d(e)$, which bears no incentive effect. Integration (regime 2) arises if and only if it generates a higher social surplus than non-integration (regime 1), namely $W^2 > W^1$. The hint is strictly proved in the following.

Proposition 2 *Fix* $i = \bar{i}$. *If* $c_e''' \geq 0$ *and* $d''' \leq 0$, *then* $\frac{d(W^2 - W^1)}{dB} > \chi$ *for some* $\chi > 0$. *That is, integration arises in equilibrium if and only if the benefit of coordination* (B) *is larger than some critical level.*

Proof. The proof is put into the appendix. The difficulty is that $\widehat{T}$ changes with B. ■

We finish examining the trade-off between control and ex post incentive. We move on to examine the case of the ex ante incentive.

4.2 Control versus Ex Ante Incentive (i)

In this subsection, assume $e(t) = \bar{e} > 0$ for $t \geq 0.5$ (when $t < 0.5$ the specific project is chosen under both regimes and $e(t) = e(0.5)$), so that ex post incentive does not matter, and for simplicity, suppress argument $\bar{e}$ in this subsection, and without loss of generality let $c_e(\bar{e}) = 0$. Thus, if A invests i at date 1, the social value of the specific project is $v_s(i) \equiv d(i) + B$.

Without the ex post incentive problem, $V(i,t) = tv_s(i)$ for all t, and by (1), $\widehat{t} = 1$, namely the specific project is always ex post efficient. Then $\widehat{T} = 1$, as $\widehat{T} \geq \widehat{t}$. That is, the specific project is always chosen under integration; intuitively, the specific project cannot be negotiated away when it is the default choice, since its efficiency is common knowledge. However, it is not chosen with a positive probability under non-integration where the general project is the default choice; this is because of the same reason as that by which the monopolist under-supplies customers, or more generally, because of the friction of bargaining, to overcome which the efficiency gain must be great enough in order to negotiate away the default project.

Under regime 1, the social surplus is $W^1(i) = \frac{15}{16}v_s(i)$, where the coefficient $\frac{15}{16}$ comes as follows. Under the regime, with probability $\frac{3}{4}$, the specific project is chosen, of which the social surplus is $1 \cdot v_s$, and with probability $\frac{1}{4}$ (namely when $t \geq 0.5$ and A offers tioli), the general project is chosen, of which the social surplus is $t \cdot v_s$, with the average of t being $E(\widetilde{t}|0.5 \leq \widetilde{t} \leq 1) = \frac{3}{4}$; therefore, the overall coefficient is $\frac{3}{4} \cdot 1 + \frac{1}{4} \cdot \frac{3}{4} = \frac{15}{16}$. Under regime 1, A's payoff is $U^1(i) = \frac{9}{16}v_s(i)$: when the specific project is chosen, he reaps half of the value, namely $\frac{1}{2} \cdot v_s$, and when the general project is chosen, he obtains the full value, namely $t \cdot v_s$, with the average of $\frac{3}{4}v_s$ (as calculated above); therefore, his expected payoff is $[\frac{3}{4} \cdot \frac{1}{2} + \frac{1}{4} \cdot \frac{3}{4}] \cdot v_s = \frac{9}{16}v_s$. Under Regime 2, the social surplus is $W^2(i) = v_s(i)$, as the specific project is certainly chosen, and accordingly A's payoff is $U^2(i) = \frac{1}{2}v_s(i)$. Therefore, the investment level under regime 1 is $i^1 = \arg\max \frac{9}{16}v_s(i) - c_i(i)$ and that under regime 2 is $i^2 = \arg\max \frac{1}{2}v_s(i) - c_i(i)$. Certainly, $i^1 > i^2$, as $\frac{9}{16} > \frac{1}{2}$; namely integration induces incentive loss.

B bears no incentive effect and hence $i^1$and i^2 are independent of B. Then the difference in the ex ante social surplus between the two regimes is $W^1 - W^2 = W^1(i^1) - W^2(i^2) = \frac{15}{16}(d(i^1) + B) - [d(i^2) + B]$. It follows that $\frac{d(W^1 - W^2)}{dB} = -\frac{1}{16} < 0$. That is, $W^2 > W^1$ if and only if the benefit of coordination (B) is large enough.

Altogether, we have,

Proposition 3 *Fix $e = \overline{e}$. Compared to non-integration, integration generates no loss of control, but induces loss in the agent's incentive of making ex ante investment. Integration arises if and only if the benefit of coordination (B) is large enough.*

5 Empirical Evidences

Compared to the literature on the theory of the firm, which focuses on incentives, this paper underlines control and makes two points. One, integration is driven by the benefit of coordination. The other, centralized ownership of physical capital (namely integration) helps implement coordination, because it enhances control over key human capitals. This section present two evidences for these points.

5.1 GM-Fisher Re-examined

The event that General Motors acquired all Fisher Body's interest in 1926 was extensively cited in the literature on theory of the firm since Klein et al (1978). This classic story is re-examined by Casadesus-Masanell and Spulber (2000), Coase (2000), and Freeland, all published in *Journal of Law and Economics.* They make three points.

First, their common point is that hold-up problem and the relationship-specific physical investment were not problems at all when GM acquired Fisher Body, and there existed no other important incentive problems either.

Second, the integration was driven by the benefit of coordination, as Casadesus-Masanel and Spulber (2000) note that "vertical integration was directed at improving coordination of production and inventories, assuring GM of adequate supplies of auto bodies, and providing GM with access to the executive talents of the Fisher brothers" (page 67). Let us elaborate further. The integration happened in 1926, though GM had acquired part of Fisher's interest before, exactly because about then closed bodies were coming to have strategic importance.[8] That is, the benefits of coordination became high. From 1924, the automobile market began to transform, "the design and the styling of closed bodies became the primary method of achieving product differentiation and defining a new line of cars" (Freeland (2000), page52). Responding to that transformation, GM took the "policy of introducing annual model changes…", which "would require ongoing consultation and coordination between Fish and the car divisions" (both

[8] Freeland (2000) notes, "(A) second factor contributing to vertical integration was Fisher's increasing strategic importance" (page 52).

from Freeland (2000), page 50).

Third, in order to implement the coordination, it is critical to retain and control Firsher brothers' human capital. Freeland (2000) notes that "the primary factors leading to vertical integration were GM management's fears over the Fisher brothers' impending departure, coupled with problems of financing new body plants" (page 33) and that "GM's management believed that Fisher's physical assets would remain relatively useless without the continued involvement of the Fishers" (page 53). And Casadesus-Masanel and Spulber (2000) note that "vertical integration was directed at ... providing GM with access to the executive talents of the Fisher brothers" (page 67).

Therefore, GM-Fisher story well supports this papers' points.

5.2 Retail Contracting

Manufacturers sell their product to consumers through the retail outlets owned by themselves (vertical integration) or through independent retailers (non-integration). On this choice, extensive empirical work has been done, of which Lafontaine and Slade (1997) provide a good survey. They point out that retail contracting generally involves no important relationship-specific assets or investment. Besides, Lafontaine and Shaw (2001) show that after eight or more years of development franchisors generally maintain a stable rate of company-owned outlets to the franchised ones. They find that the stable rates vary considerably across sectors, and that brand-name value is a primary determinant, with franchisors of high values brandnames targeting high rates of company ownership. They argue that that is because those franchisors need to exert more direct managerial control over outlets to avoid or to reduce the free riding of franchisees on the brandnames. This is consistent with the point of this paper that it is driven by the benefit of coordination. Moreover, in some cases, the effects on brandnames are positively measured by "outlet size" or "previous experience required". They point out that the effects of these two variables on company ownership rate is inconsistent with agency theories, which instead predict that the larger the size or the higher the experience, the bigger the monitoring costs and hence the less the company ownership.

6 Conclusion

The paper studies how the principal can enhance her control over the agent's human capital by acquiring the critical capital for him to create value and how the enhancement in control entails loss in the agent's incentive of making investment ex ante and exerting effort ex post.

Control aims to implement win-lose coordination, namely to have the agent do the specific project that fits the principal's particular need but does not benefit the agent immediately. In this paper, only the agent knows how to operate with the capital, the ownership of which, therefore, does not spontaneously convey decision rights on the project choice; indeed, the project choice is always decided by the bargaining between the principal and the agent. However, the specific project is more likely to be chosen when the principal owns the capital than when the agents owns it. This is because the default choice is the specific project in the former case and the general project in the latter, and the default project is prone to be chosen: since there is friction of bargaining, in the form of information asymmetry in this paper, the default project is negotiated away only if the efficiency gain is great enough.

Control entails incentive loss, because the win-lose nature of the coordination necessarily draws A into a hold-up situation. Indeed, if doing the specific project, A only reaps half of its value, since P is the only buyer of his product, while he reaps the full value if doing the general project. The specific project is thus associated with incentive loss, in relation to both ex ante human capital investment and ex post effort.

Therefore, the trade-off between control and incentive decides the boundary of the firm. The paper shows that the integration (principal-ownership) induces too much coordination and non-integration (agent-ownership) induces too little, and that integration happens if and only if the benefit of coordination is large enough.

Appendix: the proof of Proposition 2

To prove the proposition, two lemmas concerning concave functions are applied often and are given below.

Lemma A1: If $f(\cdot) \geq 0$ is concave and $f(0) = 0$, $\frac{f(y)}{f(x)} \geq \frac{y}{x}$ for $0 < y < x$.

Proof: $f(y) = f(\frac{y}{x}x + \frac{x-y}{x}0) \geq \frac{y}{x}f(x) + \frac{x-y}{x}f(0)$. QED

Lemma A2: if $f(\cdot)$ is concave, then $\int_a^b f(t)dt \leq f(\frac{b+a}{2})(b-a)$.

Proof: for any $x \in [0, \frac{b-a}{2}]$, $f(\frac{b+a}{2}) - f(\frac{b+a}{2} - x) \geq f'(\frac{b+a}{2})x \geq f(\frac{b+a}{2} + x) - f(\frac{b+a}{2})$. QED

To simplify notations, let $e_t = e(t), d_t = d(e(t))$ and $D(t) = \max_e td(e) - c_e(e)$. Then $V(t) = D(t) + tB$, $e_0 = d_0 = 0$, $v_s(e_t) = d_t + B$, and in particular, $\widehat{v} = v_s(e_{0.5}) = d_{0.5} + B$.

By figure 4, the difference between the two regimes is that for $0.5 < t < \widehat{T}$, the specific project is chosen under regime 2 with a probability 0.5 higher than that under regime 1. The social surplus of the specific project is $V(0.5) + 0.5\widehat{v}$ and that of the general project is $V(t)$. Therefore, the difference in the ex ante social surplus between the two regimes, $W^1 - W^2$, satisfies $2(W^1 - W^2)(B) = \int_{0.5}^{\widehat{T}} V(t) - (V(0.5) + 0.5\widehat{v})dt$. Note that $V(t) - (V(0.5) + 0.5\widehat{v}) = D(t) - D(0.5) - d_{0.5} + (t-1)B$ and hence its derivative to B equals $t - 1$. Therefore,

(A3): $2\frac{d(W^1-W^2)(B)}{dB} = \int_{0.5}^{\widehat{T}}(t-1)dt + (V(\widehat{T}) - V(0.5) - 0.5\widehat{v})\frac{d\widehat{T}}{dB}$.

$\int_{0.5}^{\widehat{T}}(t-1)dt$ measures the coordination loss and is thus negative; and it is easy to be calculated. However, $V(\widehat{T}) - V(0.5) - 0.5\widehat{v} = V(\widehat{T}) - V(\widehat{t}) > 0$, as $V(\widehat{t}) = V(0.5) + 0.5\widehat{v}$ by (1). To prove the proposition, we estimate $\frac{d\widehat{T}}{dB}$ and $V(\widehat{T}) - V(0.5) - 0.5\widehat{v}$.

Lemma A4: $\frac{d\widehat{T}}{dB} = \frac{2(1-\widehat{T})}{2d_{\widehat{T}}+2B-(1-\widehat{T})d'(e_{\widehat{T}})e'_{\widehat{T}}}$.

Proof: By lemma 3, $\widehat{T}$ is defined by $V(\widehat{T}) = \widehat{F} + V(\frac{1}{2})$ where $\widehat{F} > 0.5\widehat{v}$ is the solution of P's problem: $\max_F \Pr(\widetilde{t}|V(\widetilde{t}) - F) \geq V(0.5))(F - 0.5\widehat{v})$. By variable transformation $V(t) = F + V(0.5)$, the problem becomes $\max_t(1-t)(V(t) - V(0.5) - 0.5\widehat{v})$ and $\widehat{T}$ is its solution. Given that $V'(t) = v_s(e_t) = d_t + B$, it satisfies the first order condition: $-V(\widehat{T}) + V(0.5) + 0.5\widehat{v} + (1 - \widehat{T})(d_{\widehat{T}} + B) = 0 \Leftrightarrow -D(\widehat{T}) + D(0.5) + 0.5d_{0.5} + (1-\widehat{T})(d_{\widehat{T}} + 2B) = 0$. The lemma follows from the implicit function theorem and $D' = d_t$. QED

Lemma A5: when $c_e'''(.) \geq 0$ and $d'''(.) \leq 0$, e_t is concave.

Proof: e_t is decided by the first order condition $td'(e) = c_e'(e)$. Then $e''(t) = \frac{d''(c''-td'')-d'(c'''-d''-td''')}{(c''-td'')^2} < 0$, given the conditions in the lemma and $d'(e) > 0, c''(e) > 0, d''(e) < 0$. QED

Then d_t is also concave, since it is the compound of a concave function $(d(e))$ with another concave function $(e(t))$.

Lemma A6: $\frac{d\widehat{T}}{dB} < \frac{2(1-\widehat{T})}{d_{\widehat{T}}}$.

Proof: As d_t is also concave and $d_0 = 0$, $d_t \geq d'(e_t)e'_t t$. Obviously $\widehat{T} > 0.5$. Therefore $d_{\widehat{T}} \geq d'(e_{\widehat{T}})e'_{\widehat{T}}\widehat{T} > d'(e_{\widehat{T}})e'_{\widehat{T}}(1-\widehat{T})$. Then $2d_{\widehat{T}} + 2B - (1-\widehat{T})d'(e_{\widehat{T}})e'_{\widehat{T}} > d_{\widehat{T}}$. This lemma then follows Lemma A4. QED

Lemma A7: $\widehat{T} \geq \frac{\sqrt{3}}{2}$.

Proof: By (2), $V(\widehat{T}) - V(0.5) = \widehat{F} > 0.5\widehat{v} = 0.5v_s(e_{0.5})$, which, together with $V'(t) = v_s(e_t)$, implies that $\int_{0.5}^{\widehat{T}} v_s(e_t) > 0.5v_s(e_{0.5})|_{\text{by lemma A2}} \Rightarrow v_s(e(\frac{\widehat{T}+0.5}{2}))(\widehat{T}-0.5) > 0.5v_s(e_{0.5}) \Leftrightarrow 2(\widehat{T} - 0.5) > \frac{v_s(e_{0.5})}{v_s(e(\frac{\widehat{T}+0.5}{2}))}|_{\text{by lemma A1}} > \frac{0.5}{\frac{\widehat{T}+0.5}{2}}$, where the last inequality applies the fact that $v_s(e(t))$ is concave. Hence, $\widehat{T}^2 - 0.25 > 0.5$. QED

We have done enough as to estimating $\frac{d\widehat{T}}{dB}$ and move on to estimate $V(\widehat{T}) - V(0.5) - 0.5\widehat{v}$.

Lemma A8: $V(\widehat{T}) - V(0.5) - 0.5\widehat{v} < \widehat{T}d_{\widehat{T}} - d_{0.5}$.

Proof: $V(\widehat{T}) - (V(0.5) + 0.5\widehat{v}) = \widehat{T}v_s(e_{\widehat{T}}) - c_e(e_{\widehat{T}}) - v_s(e_{0.5}) + c_e(e_{0.5})) < \widehat{T}v_s(e_{\widehat{T}}) - v_s(e_{0.5}) = \widehat{T}d_{\widehat{T}} - d_{0.5} - (1-\widehat{T})B < \widehat{T}d_{\widehat{T}} - d_{0.5}$. QED

Finally estimate the right hand side of (A3). By Lemmas A6 and A8, $2\frac{d(W^1-W^2)(B)}{dB} < -(\widehat{T}-0.5)(1-\frac{\widehat{T}+0.5}{2}) + (\widehat{T}d_{\widehat{T}} - d_{0.5})\frac{2(1-\widehat{T})}{d_{\widehat{T}}} \leq -(\widehat{T}-0.5)(1-\frac{\widehat{T}+0.5}{2}) + 2(1-\widehat{T})(\widehat{T}-\frac{0.5}{\widehat{T}})$, where the last inequality applies $\frac{-d_{0.5}}{d_{\widehat{T}}} \leq \frac{-0.5}{\widehat{T}}$, derived from A1. To show that $\frac{d(W^1-W^2)(B)}{dB}$ is upper bounded by a strictly negative constant, it suffices to show that $\min_{1\geq\widehat{T}\geq\frac{\sqrt{3}}{2}}(\widehat{T}-0.5)(1-\frac{\widehat{T}+0.5}{2}) - 2(1-\widehat{T})(\widehat{T}-\frac{0.5}{\widehat{T}}) > 0$, where $\widehat{T} \geq \frac{\sqrt{3}}{2}$ is from lemma A7. Rearrange the terms, the function to be minimized equals $\frac{1}{4\widehat{T}}g(\widehat{T})$, where $g(t) = 6t^3 - 4t^2 - 5.5t + 4$. In order to show $\min_{1\geq t\geq\frac{\sqrt{3}}{2}}\frac{g(t)}{4t} > 0$, it suffices to show $\min_{1\geq t\geq\frac{\sqrt{3}}{2}} g(t) > 0$.

It is easy to check that within $[0.5, 1]$, $g'(t) = 0$ has unique solution $t = \frac{4+\sqrt{115}}{18} < \frac{\sqrt{3}}{2}$. It follows that $g'(t)$ have the sign for $1 \geq t \geq \frac{\sqrt{3}}{2}$. Note that $g'(1) > 0$. Therefore, $g'(t) > 0$ for $t \in [\frac{\sqrt{3}}{2}, 1]$ and $\min_{1\geq t\geq\frac{\sqrt{3}}{2}} g(t) = g(\frac{\sqrt{3}}{2}) = \frac{2-\sqrt{3}}{2} > 0$. **Q.E.D.**

References

[1] Aghion, P., M. Dewatripont, and P. Rey (2004), "Transferable Control," *Journal of the European Economic Association*, II, 115-38.

[2] Aghion, P. and J. Tirole (1997), "Formal and Real Authority in Organizations," *Journal of Political Economy*, 105, 1-29.

[3] Alonso, R., W. Dessein, and N. Matouschek (2008), "When Does Coordination Require Centralization?" *American Economic Review*, 98, 145-179.

[4] Anderson, E. and D. Schmittlein, (1984), "Integration of the Sales Force: An Empirical Examination", *Rand Journal of Economics*, 15, 385-395.

[5] Athey, Susan and John Roberts (2001), "Organizational Design: Decision Rights and Incentive Contracts", *American Economic Review Papers and Proceedings* 91(2), 200-5.

[6] Baker, G., and T. Hubbard (2000), "Contractibility and Asset Ownership: On-board Computers and Governance in U.S. Trucking," Mimeo, Harvard Business School.

[7] Baker, G., R. Gibbons and K. Murphy (2002), "Relational Contract and the Theory of the Firm", *Quarterly Journal of Economics*, 117, 39-84.

[8] Baker, G., R. Gibbons and K. Murphy (2008), "Strategic Alliances: Bridges between 'Islands of Conscious Power'," *Journal of the Japanese and International Economies*, 22, 146-163.

[9] Bolton, P. and M. Dewatripont (2005), Contract Theory. Cambridge, MA: MIT Press.

[10] Casadesus-Masanell, R. and D. F. Spulber (2000), "The Fable of Fisher Body", *Journal of Law and Economics*, 43, 67-104.

[11] Chandler, A. (1977), *The Visible Hand: The Managerial Revolution in American Business*, Cambridge: Harvard Uni Press.

[12] Coase, R. H. (1937), "The Nature of the Firm", *Economica*, New Series, IV, 386-405.

[13] Coase, R. H. (2000), "The Acquisition of Fisher Body by General Motors", *Journal of Law and Economics*, 43, 15-31.

[14] Dessein,W., L. Garicano, and R. Gertner (2008), "Organizing for Synergies", working paper, University of Chicago.

[15] Freeland, R. F. (2000), "Creating Holdup through Vertical Integration: Fisher Body Revisited", *Journal of Law and Economics*, 43, 33-66.

[16] Friebel, G. and M. Raith (2007), "Resource Allocation and Firm Scope", mimeo, University of Tolouse and University of Rochester.

[17] Gibbons, R. (2004), "Four Formal(izable) Theories of the Firm", manuscript.

[18] Grossman, S. and O. Hart (1986), "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94, 691-719.

[19] Hart, O. (1989), "An Economist's Perspective on the Theory of the Firm", in P. J. Buckley and J. Michie ed. *Firms, Organizations and Contracts, A Reader in Industrial Organization*, New York and London, Oxford Univ. Press, 199-218.

[20] Hart, O. (1995), *Firms, Contracts, and Financial Structure*, Oxford: Oxford University Express.

[21] Hart, O. and B. Holmstrom (2009), "A Theory of Firm Scope," forthcoming, *Quarterly Journal of Economics*.

[22] Hart, O. and J. Moore (1990), "Property Rights and the Nature of the Firms," *Journal of Political Economy*, 98, 1119-1158.

[23] Holmstrom, B. (1982), "Moral Hazard in Teams," *Bell Journal of Economics*, 13, 324-340.

[24] Holmstrom, B. (1999), "The Firm as a Subeconomy," *Journal of Law, Economics, and Organization*, 15, 74-102.

[25] Holmstrom, B. and P. Milgrom (1991), "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design," *Journal of Law, Economics, and Organization*, 7, 24-52.

[26] Holmstrom, B. and P. Milgrom (1994), "The Firm as an Incentive System", *American Economic Review*, 84, 972-91.

[27] Holmstrom B and J. Roberts (1998), "The Boundaries of the Firm Revisited," *Journal of Economic Perspectives*, 12, 73-94.

[28] Klein, B., R. Crawford and A. Alchian (1978), "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," *Journal of Law and Economics*, 21, 297-326.

[29] Lafontaine, F. (1995), "Pricing Decisions in Franchised Chains: a Look at the Restraunt and Fast-Food Industry", NBER working paper 5427.

[30] Lafontaine, F. and K. L. Shaw (2001), "Targeting Managerial Control: Evidence from Franchising", NBER working paper 8416.

[31] Lafontaine, F. and M. E. Slade (1997), "Retail Contracting: Theory and Practice", *Journal of Industrial Economics*, XLV, 1-25.

[32] Martin, R. E. (1988), "Franchising and Risk Management", *American Economic Review*, 78, 954-968.

[33] Maskin, E., Y. Qian and C. Xu (2000), "Incentives, Information, and Organizational Form", *Review of Economic Studies*, 67, 359-78.

[34] Mirrlees, J. (1999), "The Theory of Moral Hazard and Unobservable Behavior, Part I," *Review of Economic Studies*, 66, 3-22.

[35] Norton, S. W. (1988), "An Empirical Look at Franchising as an Organizational Form", *Journal of Business*, 61, 197-217.

[36] Qian, Y., G. Roland and C. Xu (2006), "Coordination and Experimentation in M-Form and U-Form Organizations", *Journal of Political Economy*, 114(2), 366-402.

[37] Rajan, R. G. and L. Zingales (2001), "The Firm as a Dedicated Hierarchy", *Quarterly Journal of Economics,* 116, 805-851.

[38] Rantakari, H. (2008), "Governing Adaptation," *Review of Economic Studies*, 75, 1257-1285.

[39] Simon, H. (1951), “A Formal Theory of the Employment Relationship”, *Econometrica*, 19, 293-305.

[40] Van den Steen, E. (2006), "The Limits of Authority: Motivation versus Coordination", mimeo, MIT.

[41] Van den Steen, E. (2009), “Interpersonal Authority in a Theory of the Firm,” forthcoming, *American Economic Review*.

[42] Williamson, O. (1971), “The Vertical Integration of Production: Market Failure Considerations”, *American Economic Review*, 61, 112-23.

[43] Williamson, O. (1991), “Comparative Economic Organization: The Analysis of Discrete Structural Alternatives”, *Administrative Science Quarterly*, 36, 269-296.